

28.

Caudal Skeleton of Bermuda Shallow Water Fishes. III.
Order Iniomi: Synodontidae.¹

GLORIA HOLLISTER

Department of Tropical Research.

(Text-figures 1-18).

OUTLINE.

	Page
INTRODUCTION	385
KEY	386
Bermuda Iniomi:	
Synodontidae: <i>Trachinocephalus myops</i>	387
<i>Synodus foetens</i>	391
<i>Synodus intermedius</i>	396

INTRODUCTION.

This is the third of a series of papers dealing with the caudal skeleton of Bermuda fishes². The shallow-water Iniomi of Bermuda are represented by one family, two genera and three species.

In identifying specimens of the genus *Synodus*, before preparing them for osteological study, all the material runs to *S. intermedius* and *S. foetens*. All characters agree with Norman's "A Revision of the Lizard-Fishes of the Genera *Synodus*, *Trachinocephalus*, and *Saurida*." P.Z.S. of London, 1935.

For Caudal Fin Terminology, complete Bibliography, and method of preparing specimens for this study refer to Part I.

The length of specimens in this paper is standard length unless otherwise stated.

I am indebted to the United States National Museum for two specimens of *Trachinocephalus myops*.

This opportunity is taken to thank Dr. William Beebe, Director of this department, and Mr. John Tee-Van, General Associate, for their cooperation.

The drawings are by Mr. George Swanson and the author.

¹ Contribution No. 548, Department of Tropical Research, New York Zoological Society. Contribution from the Bermuda Biological Station for Research Inc.

² Caudal Skeleton of Bermuda Shallow Water Fishes. I. Order Isoospondyli: Elopidae, Megalopidae, Albulidae, Clupeidae, Dussumieriidae, Engraulidae. *Zoologica*, New York Zoological Society, Vol. XXI, Dec. 31, 1936.

Caudal Skeleton of Bermuda Shallow Water Fishes. II. Order Percomorphi, Suborder Percosoes: Atherinidae, Mugilidae, Sphyraenidae. *Zoologica*, New York Zoological Society, Vol. XXI, Oct. 7, 1937.

KEY TO CAUDAL FIN OF BERMUDA SHALLOW WATER INIOMID FISHES.

I S
N y
I n
O o
M d
I t
e a
e

Group I

Trachinocephalus myops

1 simple vertebra, anterior to true caudal, without ribs, epipleural spines and haemal process.

Abdominal ribs present beyond the anterior margin of anal fin, extending to about mid-length and above 7th anal ray.

55 total vertebrae.

46 trunk vertebrae.

Sub-Group A

Synodus foetens

4 simple vertebrae anterior to true caudal.

Posterior interhaemal anal spine higher than long.

58 total vertebrae.

38 trunk or abdominal vertebrae with ribs.

Group II

4 to 7 simple vertebrae, anterior to true caudal, without ribs, epipleural spines and haemal processes.

Abdominal ribs absent beyond the anterior margin of anal fin.

58 or 49 total vertebrae.

Sub-Group B *Synodus intermedius*

6 or 7 simple vertebrae anterior to true caudal.

Posterior interhaemal anal spine longer than high.

49 total vertebrae.

30 trunk or abdominal vertebrae with ribs.

This paper deals principally with the adult fishes, as does Part I on Bermuda Isospondyli and Part II on Bermuda Percomorphi, suborder Percosoces.

The Synodontidae are unlike the families studied in Parts I and II in having between the trunk and the typical caudal region vertebrae which lack ribs, characteristic of the trunk, and which also lack closed haemal arches bearing haemal spines, characteristic of the caudal. This area is immediately posterior to the abdominal or trunk region and dorsal to the anal fin whose interhaemals project upward almost to the vertebrae. Definite bottom living habits of this elongate fish may be responsible for the ventral modification of the vertebrae in this region above the anal fin.

In *Synodus* the posterior pair of ribs is dorsal to the anterior margin of the anal fin. In *Trachinocephalus* the posterior pair of ribs is dorsal to the anal fin at its mid-length. In a broad sense the caudal region of the synodonts includes all the vertebrae posterior to the last abdominal or trunk vertebra bearing ribs. In this paper the general caudal is divided into the anterior or precaudal and the posterior or true caudal. The precaudal includes all of the modified vertebrae posterior to the last trunk vertebra and anterior to the true caudal. The true caudal is the typical caudal, the vertebrae of which have closed haemals bearing spines.

The differences in the total vertebral counts of the three species is found in the trunk region and there is only slight variance in the counts of the precaudal and the caudal.

In the trunk region the ventral projections or stumps from the bases of the centra are called parapophyses, according to Starks' "Synonymy of the Fish Skeleton." In the precaudal and the true caudal regions the ventral projections are called zygapophyses according to the definition of caudal bones in Part I.

The true caudal of *S. foetens* and *S. intermedius* are so essentially similar that no illustrations have been included of the latter. The differences are described in the text.

The symbols used are: AD, adipose; AN, anal fin; BA, basiost; C, centrum; EP, epural; ES, epipleural spine; HA, haemal arch; HP, haemal process; HS, haemal spine; IS, interhaemal spine; NA, neural arch; NP, neural process; NS, neural spine; P, parapophysis; R, rib; SNP, specialized neural process; UN, uroneural; UR, urostyle; Z, zygapophysis; 1, 2, 3, etc., hypurals.

1. *Trachinocephalus myops* (Forster).

(Text-figs. 1-4).

Diagnostic Characters:

1 simple vertebra anterior to the true caudal without ribs, epipleural spines and haemal process.

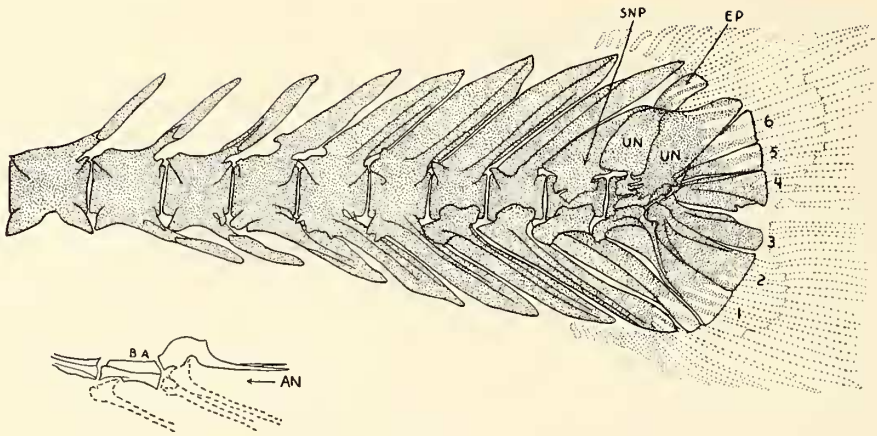
Posterior pair of ribs at about mid-length of anal fin, dorsal to the 7th anal ray.

Epipleural spines present above the entire length of the anal fin.

Vertebral count: 46 trunk. Total 55.

Material Studied.

<i>Length.</i>	<i>KOH Cat. No.</i>	<i>Cat. No.</i>	<i>Text-fig. No.</i>
275 mm.	2201	83784 U. S. Nat. Mus.	1
90 mm.	2200	71053 U. S. Nat. Mus.	
39 mm.	2174		2, 3
29 mm.	2139		4

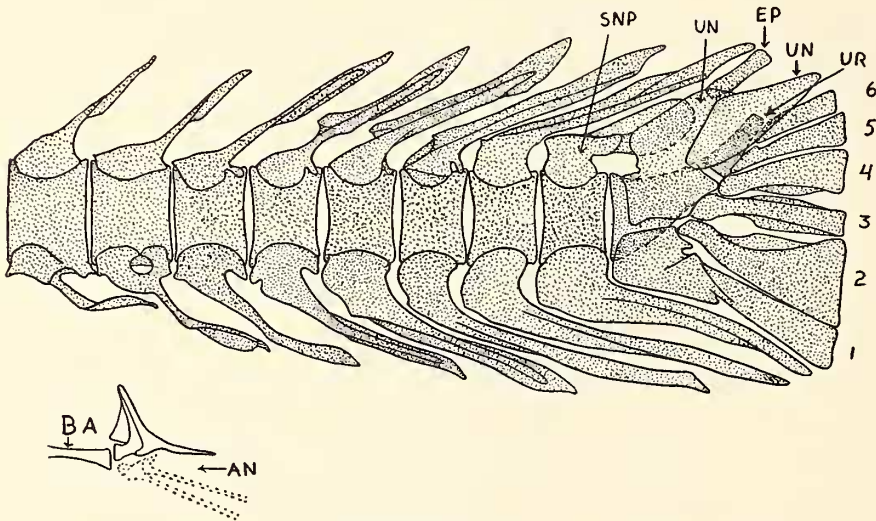


Text-figure 1.

Trachinocephalus myops. Tail of 275 mm. specimen showing the entire true caudal series following the last precaudal vertebra. ($\times 2.6$).

Caudal Osteology.

Urostyle: In the 275 mm. specimen all except the anterior margin of the urostyle is covered by the uroneurals (Text-fig. 1). The visible part of the urostyle is identical in size and shape with the penultimate centrum. The notochord extends beyond the distal margin of the hypurals between the bifid base of the ninth ray, counting up from the median line. In the 39 mm. and 29 mm. specimens, where the ossification of the uroneurals overlapping the urostyle is not as dense as in the 275 mm. specimen, separate elements of the urostyle can be seen. These are less ossified in the



Text-figure 2.

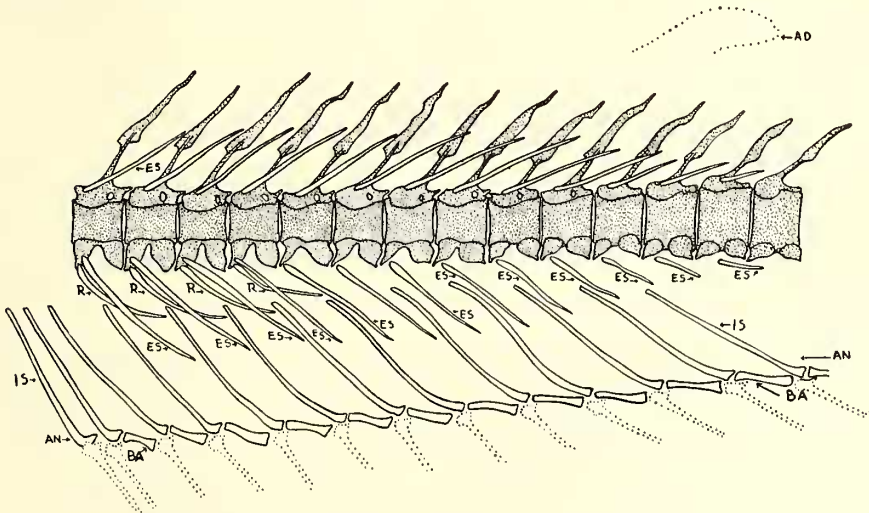
Trachinocephalus myops. Tail of 39 mm. specimen showing the entire true caudal series and the specialized neural process of the penultimate vertebra projecting between the adjacent uroneurals. ($\times 21.1$).

29 mm. fish and there is a longer unossified area between the two segments. All the elements of the urostyle in the 39 mm. specimen are more consolidated and more heavily ossified than in the 29 mm. fish (Text-figs. 2, 3, and 4).

Uroneurals: There are two pairs of uroneurals, in all the specimens examined, which overlap and cover the urostyle and almost fill the area above and between the last neural spine and the sixth hypural (Text-figs. 1, 2, and 4). By dissecting, a third pair was found fused to the distal and inner surfaces of the posterior uroneurals. Dorsally, the shape of the two large pairs of uroneurals, separately and together, differs from *Synodus foetens*. In *Trachinocephalus* the bones of both pairs of uroneurals are larger (Text-fig. 1). In *Synodus foetens* the epural, and not the uroneurals, fills most of the area above the anterior uroneurals whereas the reverse is true in *Trachinocephalus*. In this fish the posterior pair of uroneurals elongate anteriorly, covering most of the lateral parts of the anterior pair and the bases of the hypurals. In *Synodus foetens* a third pair of uroneurals is present on the lateral part of the urostyle and the posterior pair, comparable with that of *Trachinocephalus*, is entirely dorsal to the urostyle (Text-fig. 5).

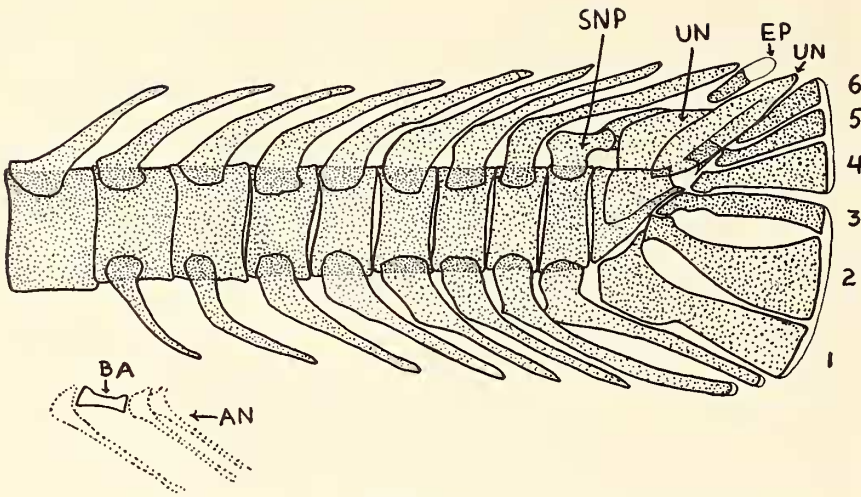
Hypurals: There are six hypurals, three below and three above the median line. There is no space between the dorsal and ventral surfaces of these bones but they remain unfused even in the largest specimen. In the smallest specimen examined a continuous band of cartilage covers the distal ends of the hypurals (Text-fig. 4).

Epurals: There is one epural in all specimens. In the 29 mm. fish the distal half is unossified (Text-fig. 4). The epural in the 275 mm. specimen is rectangular-shaped and twice as long as wide (Text-fig. 1). In *Synodus foetens* of 300 mm. the epural is a much longer bone with a slender dorsal tip which resembles the adjacent neural spine. Ventrally, it becomes broader



Text-figure 3.

Trachinocephalus myops. Precaudal series of tail of 39 mm. specimen following the last four trunk vertebrae. At the right is the one simple vertebra preceding the true caudal series. Below is the anal fin with interhaemal spines projecting dorsally and overlapping the epipleural spines. (x 13.3).



Text-figure 4.

Trachinocephalus myops. Tail of 29 mm. specimen showing the entire true caudal following the one simple vertebra of the precaudal series. Ossification is not complete, which is shown by the partly ossified epural and unossified interhaemals. A band of cartilage outlines the distal margin of the hypurals. (x 21.1).

and fills the area above the uroneurals, which are not as large as those of *Trachinocephalus*.

Specialized Neural Processes: On dissecting the neural process of the centrum preceding the urostyle, a median dagger-like projection was found which extends posteriorly within the uroneurals uniting dorsally the penultimate and urostyle centra (Text-figs. 12, 13, and 14). This is also found in *Synodus*.

Caudal Fin Ray Count:

275 mm.	13 + 9 = 22
	13 + 10 = 23
39 mm.	13 + 10 = 23
29 mm.	13 + 9 = 22

Additional Characters Worthy of Note: There are ten vertebrae between the trunk and the true caudal series which are called precaudal in this paper. These vertebrae lack ribs, characteristic of the trunk, and also closed haemals bearing haemal spines, characteristic of the typical caudal. Ventrally, the haemal canal is open between the stump-like zygapophyses. Nine centra of this series bear epipleural spines whose lengths decrease posteriorly. At the caudal end of the series there is one simple vertebra which is anterior to the beginning of the true caudal series. This vertebra lacks ribs, epipleural spines, and haemal processes. The last pair of epipleural spines is dorsal to the posterior interhaemal spine of the anal fin. Following the ten precaudals is the true caudal series consisting of nine typical caudal vertebrae, counting the urostyle segment as one. The position of the anterior true caudal vertebra is dorsal to the basistyle which articulates the posterior and penultimate anal rays. Besides the differences in the various counts one conspicuous general difference between *Trachinocephalus* and

Synodus is the much heavier development of the neural and haemal processes of the true caudal of *Trachinocephalus*.

The description, in general, was taken from the two smaller specimens because the place of capture of the larger fish was not Bermuda.

2. *Synodus foetens* (Linnaeus).

(Text-figs. 5-18).

Diagnostic Characters:

- Posterior interhaemal anal spine higher than long.
- 4 simple vertebrae, anterior to the true caudal series, without ribs, epipleural spines and haemal processes.
- Last posterior pair of ribs on the centrum which is anterior by two centra to the anterior external margin of the anal fin.
- Epipleural spines present on centra to about the mid-length of the anal fin.
- Vertebral count: 38 trunk. Total 58.

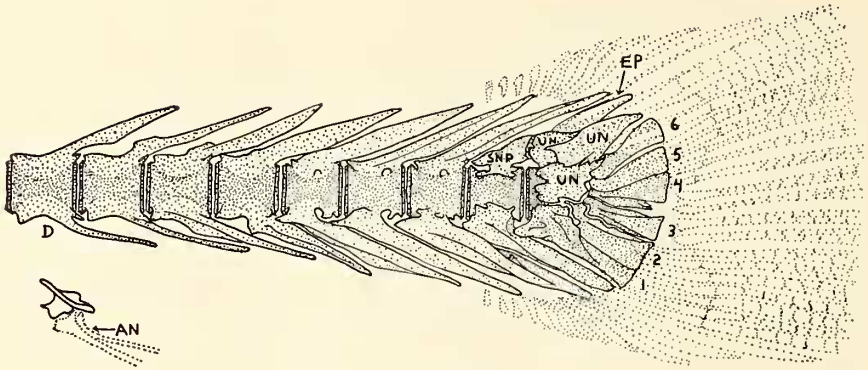
Material Studied.

Length.	KOH Cat. No.	Text-fig. No.
300 mm.	1081	5, 6, 8, 12-18
153 mm.	770	
130 mm.	997	7
75 mm.	2176	
45 mm.	2177	
33 mm.	2181	
32 mm.	2180	10
28 mm.	2182	11

Caudal Osteology.

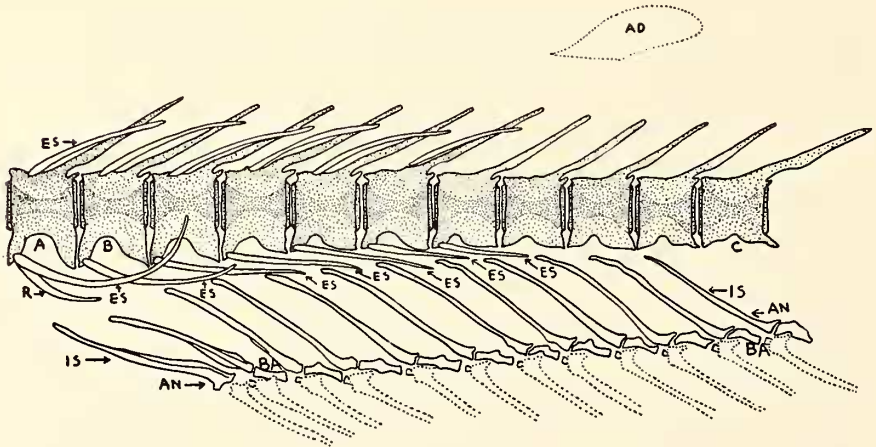
Urostyle: In the 300 mm. specimen all except the anterior margin of the urostyle segment is covered by the uroneurals and, ventrally, by the bases of the first and second hypurals. The anterior margin is identical in form with that of the preceding centrum. The clear notochord extends beyond the margin of the hypurals between the bifid base of the 10th ray, counting up from the median line. The notochord extends 5.25 mm. beyond the tips of the posterior dorsal pair of uroneurals (Text-figs. 5 & 12). In the 130 mm. specimen the posterior end of the urostyle is seen through the overlying uroneurals and located above the bases of the fourth and fifth hypurals. Beyond is a short unossified area which is followed by a small hour-glass-shaped bony segment dorsal to the bases of the fifth and sixth hypurals. The cartilaginous notochord extends between the uroneurals beyond the distal margin of the sixth hypural (Text-fig. 7). In the 75 mm. specimen the terminal bony segment, comparable with that of the 130 mm. specimen, is slightly longer and there is less unossified area between it and the preceding segment. It is more rod-like and lacks the hour-glass shape of the larger specimen (Text-fig. 8). Text-figures 10 and 11 show the development of the urostyle in specimens 32 mm. and 28 mm. in length.

Uroneurals: In the 300 mm. specimen three pairs of uroneurals overlap each other on the surface of the urostyle (Text-figs. 5 and 12). By dissecting, a diminutive fourth pair was found fused to the distal end and inner surface of the posterior-dorsal uroneurals (Text-figs. 7 and 8). In a 75 mm. specimen this small pair of uroneurals is unfused and separate from the overlapping uroneurals (Text-fig. 9). In the two smallest specimens, 32 mm. and 28 mm., only one pair of the large uroneurals is developed.



Text-figure 5.

Synodus foetens. Tail of 300 mm. specimen showing the entire true caudal and the relative position of the posterior interhaemal of the anal fin. See Text-figure 18 for front view of vertebra D. (x 2.1).



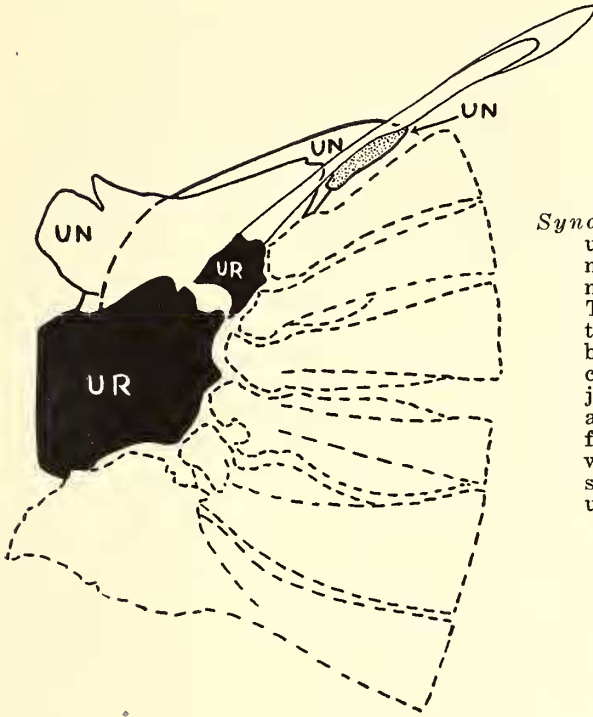
Text-figure 6.

Synodus foetens. Precaudal of tail of 300 mm. specimen following the last vertebra. At the right are the four simple vertebrae preceding the true caudal and below is the anal fin with interhaemals overlapping dorsally the ends of the epipleurals. See Text-figures 15, 16 and 17 for front views of vertebrae A, B and C. (x 2.1).

Hypurals: There are six hypurals, three below and three above the median line. Although the hypurals in the 300 mm. specimen have no space between the dorsal and ventral surfaces, these bones are not fused. In the smallest fish a band of cartilage outlines the distal margin of the hypurals (Text-fig. 10).

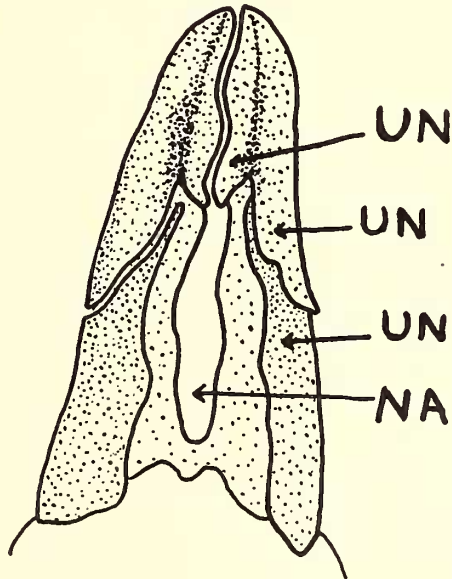
Epurals: There is one epural in specimens of all lengths. In the smallest the epural is unossified and in the 32 mm. specimen one quarter remains unossified (Text-figs. 10 and 11).

Specialized Neural Processes: In dissecting the neural process of the centrum preceding the urostyle a median dagger-like projection was found which extends posteriorly within the uroneurals uniting dorsally the penul-

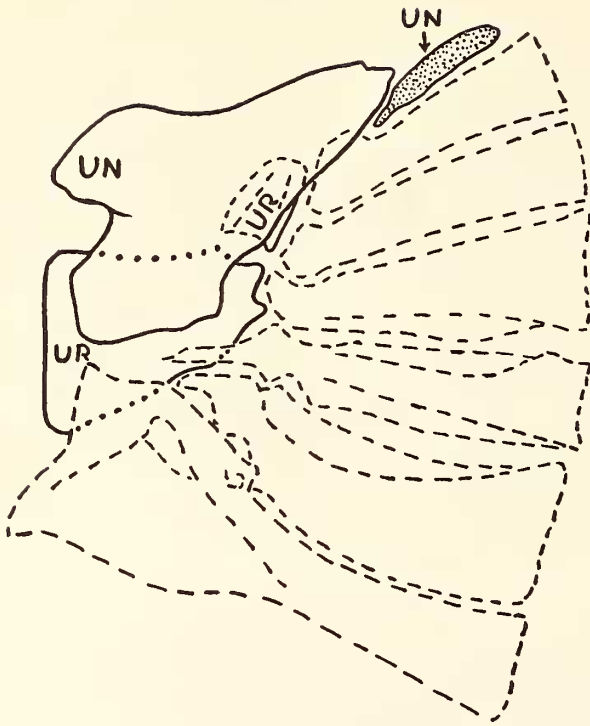


Text-figure 7.
Synodus foetens. Dissected urostyle of 130 mm. specimen with all uroneurals removed from upper side. Two ossified elements of the urostyle are shown in black and in outline, the cartilaginous notochord projecting beyond. The stippled area is one bone of the fourth pair of uroneurals which are fused to the inner surface of the dorsal uroneurals. (x 21.8).

Text-figure 8.
Synodus foetens. The overlapping uroneurals above the urostyle in the 300 mm. specimen as seen from the posterior. The upper UN represents the small uroneurals stippled in Text-figure 7. (x 11.8).

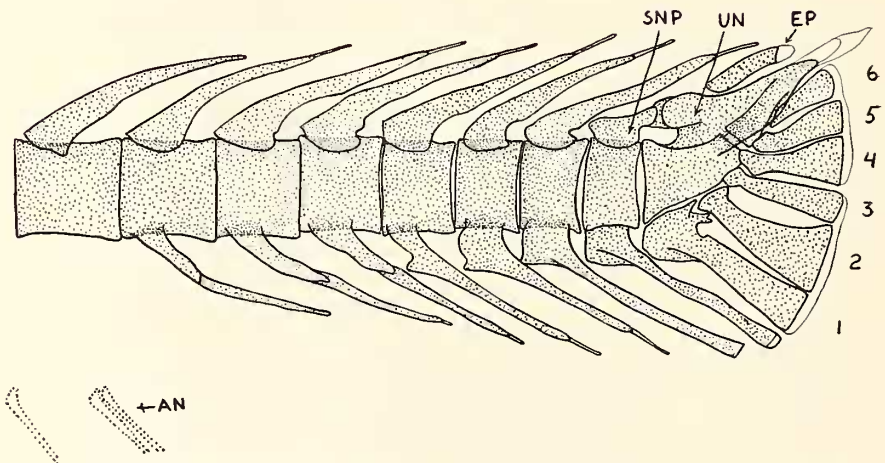


timate and urostyle centra (Text-figs. 12, 13, 14). In the smallest specimen, 28 mm., which is only partially ossified, this neural process is not present (Text-figure. 11). But in the 32 mm. fish it is present and ossified (Text-fig. 10).



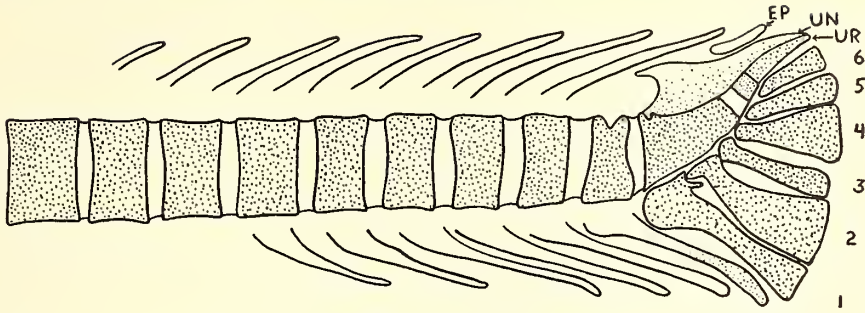
Text-figure 9.

Synodus foetens. Urostyle of 75 mm. specimen with the posterior dorsal uroneurals removed to show the small underlying pair which are unfused in this young specimen. (x 36).



Text-figure 10.

Synodus foetens. Tail of 32 mm. specimen showing entire true caudal following the posterior simple vertebra of the precaudal series. Part of the epural and none of the internal bones of the anal fin are ossified. A cartilaginous band outlines the distal margin of the hypurals. (x 26.8).



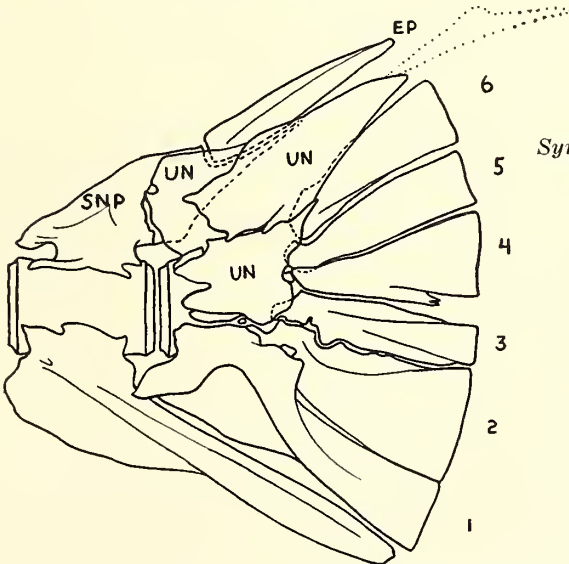
Text-figure 11.

Synodus foetens. Tail of 28 mm. specimen showing vertebral column unsegmented and only partly ossified. None of the neurals or haemals is ossified. (x 21).

Caudal Fin Ray Count:

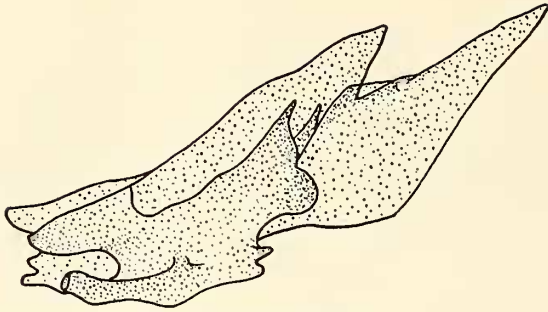
300 mm.	$12 + 10 = 22$
45 mm.	$11 + 9 = 20$
75 mm.	$13 + 10 = 23$
	$12 + 9 = 21$
32 mm.	$11 + 8 = 19$
	$9 + 10 = 19$
28 mm.	$12 + 8 = 20$
	$11 + 9 = 20$

Additional Characters Worthy of Note: There are ten precaudal vertebrae between the trunk and the true caudal series. These vertebrae lack ribs and closed haemals with haemal spines (Text-fig. 6). Ventrally, the haemals are open between the stump-like zygapophyses (Text-figs. 16 and



Text-figure 12.

Synodus foetens. Urostyle with penultimate vertebra of 300 mm. specimen showing in dashed line the median projection of the specialized neural process between the uroneurals. Also in dashed line are the bases of the hypurals which are covered by the uroneurals in the completely ossified specimen. (x 5.1).



Text-figure 13.

Synodus foetens. Lateral view of specialized neural process of penultimate centrum of 300 mm. specimen dissected to show single posterior projection which extends between the bones of two pairs of uroneurals seen in Text-figure 12. (x 10.4).

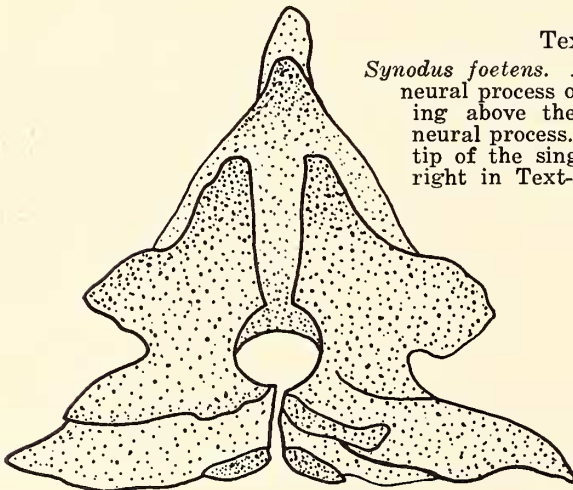
17). The six anterior centra of this series have epipleural spines whose lengths decrease posteriorly. Following the six are four simple vertebrae, anterior to the true caudal, without ribs, epipleural spines and haemal processes. The position of the last pair of epipleural spines is dorsal to the mid-length of the anal fin (Text-fig. 6). There are nine typical caudal vertebrae, counting the urostyle segment as one (Text-fig. 18). The anterior caudal vertebra is dorsal to the last interhaemal spine of the anal fin (Text-fig. 5). The interhaemals are long and stout and extend upward and in an anterior direction from the articulating basiosts almost to the centra.

3. *Synodus intermedius* (Agassiz).

Diagnostic Characters:

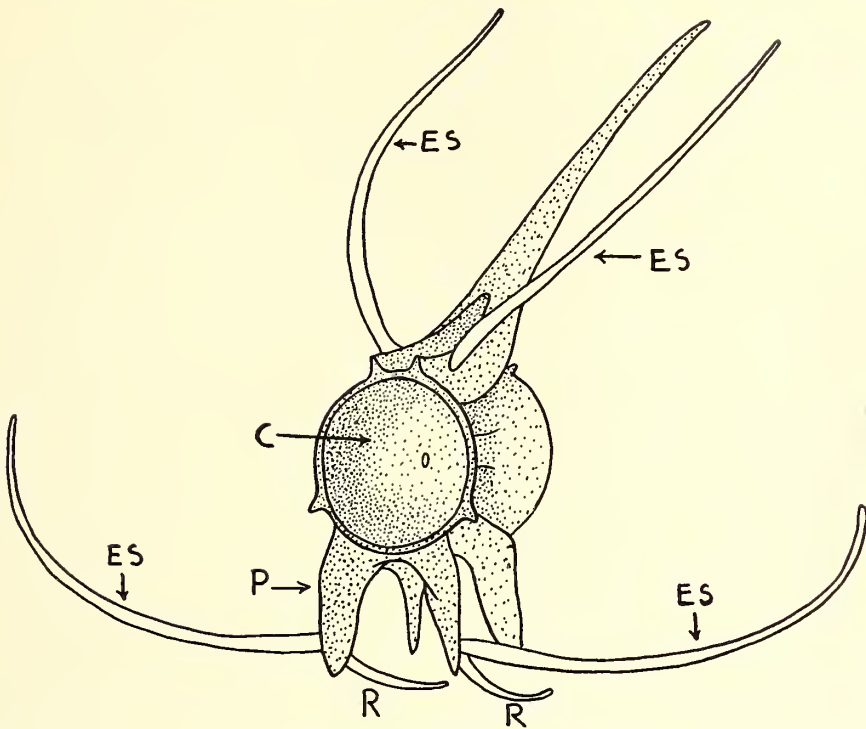
Posterior interhaemal anal spine longer than high.

6 or 7 simple vertebrae, anterior to the true caudal series, without ribs, epipleural spines, and haemal processes.



Text-figure 14.

Synodus foetens. Anterior view of specialized neural process of penultimate centrum showing above the neural canal the reduced neural process. The dorsal projection is the tip of the single median bone seen on the right in Text-figure 13. (x 23.2).



Text-figure 15.

Synodus foetens. Posterior trunk vertebra of 300 mm. specimen with ribs, epipleural spines and open haemal. This vertebra is lettered A in Text-figure 6. (x 30.3).

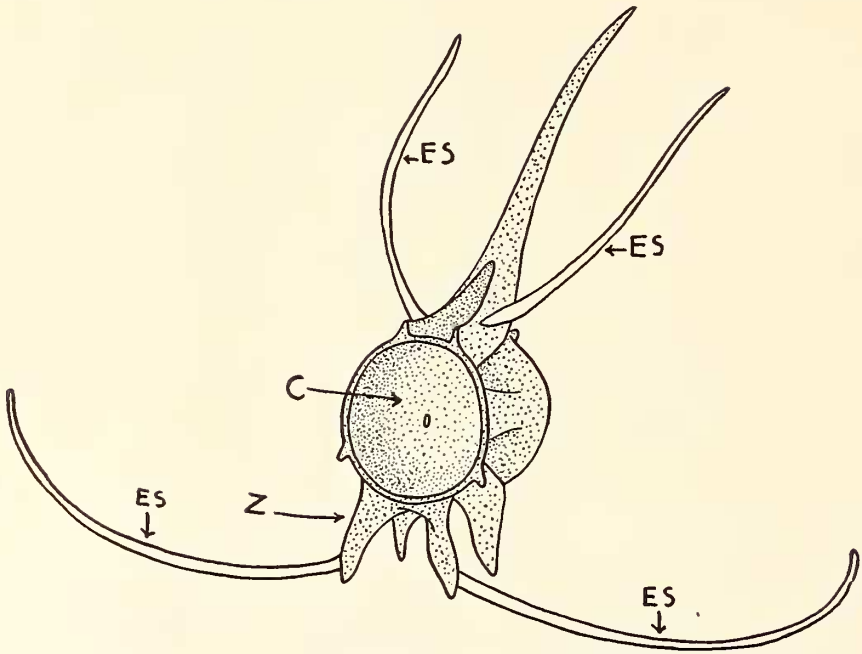
Last posterior pair of ribs on the centrum which is anterior by three centra to the external anterior margin of the anal fin.
 Last posterior pair of epipleural spines on the centrum dorsal to the external anterior margin of the anal fin.
 Vertebral count: 30 trunk. Total 49.

Material Studied.

Length.	KOH Cat. No.
270 mm.	493
202 mm.	638
135 mm.	677
50 mm.	2175

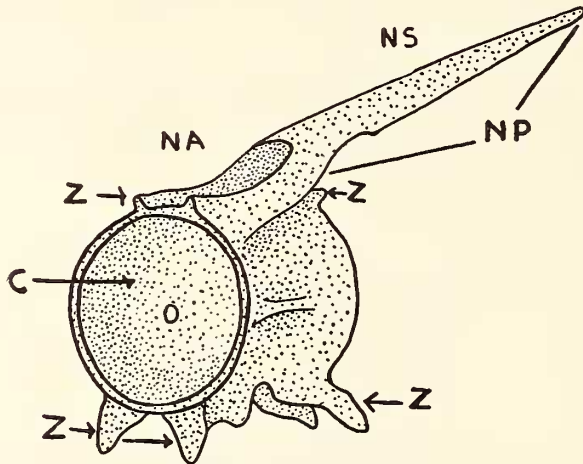
Caudal Osteology.

The general caudal pattern of *Synodus intermedius* is similar to that of *Synodus foetens* but differences of detailed structure make it easy to distinguish between the two species. *S. intermedius* is shorter and more compact than *S. foetens* as is primarily shown by a comparison of the vertebral counts. *S. intermedius* is shorter by eight to ten vertebrae, which difference is found in the trunk region. The precaudal and caudal counts of the two species are almost the same. In *S. intermedius* the anal fin is notice-



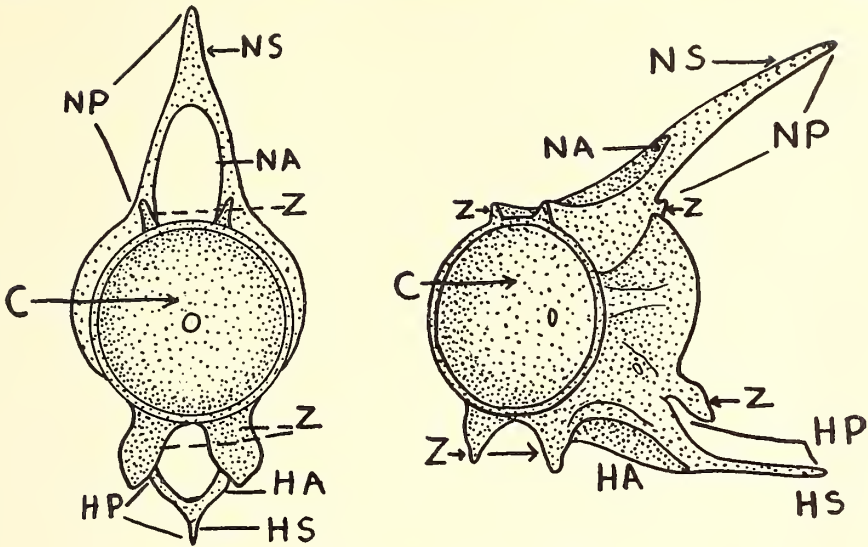
Text-figure 16.

Synodus foetens. First precaudal vertebra of 300 mm. specimen which follows the vertebra shown in Text-figure 15. It is lettered B in Text-figure 6. (x 30.3).



Text-figure 17.

Synodus foetens. The posterior simple vertebra of the precaudal series of a 300 mm. specimen which lacks ribs, epipleural spines and has an open haemal. This vertebra is penultimate to the true caudal series and is lettered C in Text-figure 6. (x 8.2).



Text-figure 18.

Synodus foetens. The anterior and first vertebra of the true caudal series of a 300 mm. specimen showing closed haemal process with haemal spine. This vertebra is lettered D in Text-figure 6. (x 6.1).

ably shorter with fewer rays and interhaemals. In the precaudal region of *S. foetens* there is a greater number of simple vertebrae which are dorsal to the entire anal fin. Epipleural spines are present on only three or four anterior centra of the precaudal series leaving six or seven simple vertebrae. On the urostyle the ventral pair of uroneurals is much smaller than that of *S. foetens*. The base of the first hypural extends dorsally covering almost the lower half of the urostyle and, from above, the base of the anterior-dorsal uroneurals extends down over the urostyle. Between these two bones and entirely lateral in position is an insignificant pair of uroneurals. The anterior hypurals are more sharply pointed and the neural processes in the precaudal area are considerably heavier than those of *S. foetens*.

Caudal Fin Ray Count:

270 mm.	$12 + 9 = 21$
135 mm.	$11 + 10 = 21$
202 mm.	$12 + 9 = 21$
	$12 + 10 = 22$
50 mm.	$12 + 10 = 22$
	$11 + 9 = 20$